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THE VARIABILITY OF WAGES

IN the treatment of the theory of wages economists have proceeded along substantially the same lines since the beginning of the science. The common method of approaching the problem, theoretically, is to assume a standard of unskilled labor in terms of which all higher grades of labor are expressed, and to establish, deductively, propositions concerning the conditions and direction of change of the standard wage. These propositions are then, explicitly or implicitly, predicated, *a fortiori*, of skilled labor. In treating the problem statistically the common method has been to form an index number, and to infer from changes in the index number corresponding changes in the average wage. The conclusions of both groups of investigators have generally, in recent years, been optimistic: the theorist teaches that the laborer tends to get what he produces, and the statistician professes to show a progressive increase in average wages. But even if these conclusions were unquestioned, we should commit a grave error in supposing that, as economists, we have contributed the necessary material upon which to base a wise labor policy. Other equally important, indeed more important, questions press for solution. What answer, based upon actual data, can the economist give to these questions: Does skilled labor hold its own in the shifting proportions of grades of labor in the various industries? Are the chances of promotion within an industry increasing or decreasing? Is the status of the laborer confined within more narrow or less narrow limits? Until these questions are answered we shall, for the most part, form our judgments as to contemporary movements according to our inclinations as determined by the social group in which our opinions have been shaped. The present paper is diffidently offered as an attempt to throw some light on the facts that must be used either as the test of our theories or as a basis for the form of speculation that is proximate to reality.

I

The chief directions of progress in the development of theoretical economics have been characterized by the recognition of the truth that the solution of the leading problems of the pure science turns upon the consideration of marginal ratios rather than of absolute quantities. The first crude machinery for the handling of the ratios that concern the economist was elaborated in the treatment of the theory of rent, and was perfected in its successive application to the remaining fundamental questions of the science by von Thünen, Cournot, Dupuit and recent deductive economists. It is believed that, when groups of measurements must be dealt with, the parallel in inductive economics is furnished by the consideration of forms of deviation from the average of the measurements rather than of the average itself alone. The introduction into social sciences of the use of this method we owe primarily to Quételet and to Cournot, and its development to Mr. Galton, Professor Edgeworth, and, above all, to Professor Pearson. In the complete treatment of our science both of these methods must be used. Problems which, because of their complexity, must be left untouched by those relying solely upon deduction may be amenable to investigation by the peculiar form of induction just described. The following study is an attempt to supply by the latter method material to fill out a lacuna due to the limitations of the former.

If the wages of a large number of representative laborers in manufactures could be ascertained, and a curve were plotted representing the functional relation between the respective rates of wages and the number of laborers receiving them, the graph, drawn in the usual way—measuring wages on a horizontal line and the corresponding number receiving them on a line drawn perpendicular to the first,—would begin to rise near the axis of ordinates, would ascend rapidly with a series of zigzags to a maximum point, and then, likewise with a series of zigzags, would descend more slowly than it rose and taper off so as to become nearly parallel with the axis of abscissas (see chart, p. 71). As the form of this curve drawn for the totality of labor varies with the progress of time, a comparison of curves plotted for two periods would obviously afford a more comprehensive view of the conditions of earnings and of the status of labor than the usual comparison of average wages. Similarly, when descending to the analysis and comparison of the conditions of wage-earning in different industries, curves could be drawn for the different industries at the same time, and for the same industries at different times, and then properly compared.

The comparison of these curves involves at least two measures: we must find a rate of wages that is representative of the group, and we must have some measure of the concentration of the individual rates of wages about the representative value. The common average wage is used to serve the first function. Its value is affected by the value of every item in the group, and, consequently, carries with it more information than other intermediate quantities. The standard deviation, which is the square root of the mean square of the deviation of the individual rates of wages from the average rate, is taken as the measure of the concentration of the group about the average. In making this choice of the second measure, I am guided by the experience of statistical biologists who, in their studies of evolution, find the variation in the standard deviation the most significant measure of the variation of the group concentration. According to the theory of evolution by natural selection,

> the more intense the struggle for existence the less is the variability, the more nearly are individuals forced to approach the type fittest to their surrounding if they are to survive. . . . The standard deviation is in fact a scientific measure of the concentration of the variation of the population about its average or mean.[1]

Professor Pearson has developed another point immediately connected with our present investigation: ". . . the one sure test of intensity of the struggle for existence is the mortality table rightly studied," and "the mortality of the artisan classes is greater than that of the middle and upper classes. We find, accordingly, that they are less variable."[2] It is, therefore, of greatest importance to know the changing conditions of the struggle for existence as indicated in the variation of the standard deviation of wages. If a comparison of the wages of an industry at two different periods showed that the average wage remained the same, the theoretical economist, relying upon average wages alone for information, would have no clue as to the forces at work altering the condition of labor. If, however, in the interval, the standard deviation had become greatly reduced, skilled labor might have been supplanted by machinery, or perhaps by women and children, and competition among the laborers might have become far more acute. It would at least be true that the chances of greatly increased wages to the average laborer would be decidedly reduced, and that the probability of a uniformity of wages and of permanency of status of the laborer would be increased.

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[1] Pearson, Chances of Death, vol. i, pp. 258 and 274.

[2] *Ibid.*, p. 258 and note.

In addition to the two fundamental measures just described, we shall have occasion to use a third, the coefficient of variation, or the measure of relative variability. Suppose we had to investigate the relative variability of wages in the two industries, boots and shoes, and tobacco. In 1900 the two fundamental measures for boots and shoes were average weekly wage $11.56 and standard deviation $4.75; and for tobacco, average weekly wage $6.37, standard deviation $3.49. It would clearly be inaccurate to say that the relative variability of wages in the two groups was in the ratio of their standard deviations. The degree of variability is the measure of trueness to type, and a variation of $4.75 from $11.56 is relatively a smaller departure than $3.49 from $6.37. The coefficient of variation is the percentage variation, or the ratio of the standard deviation to the average, multiplied by one hundred. We shall use these measures in the treatment of the data from the admirable report of the Twelfth Census on "Wages in Manufactures."

II

By the use of the measures just described we shall determine, first, whether there has actually been a general change in the wages of laborers in manufactures, and secondly, what the nature of the change has been. The government report is an exceptionally satisfactory document so far as relates to the several industries, but it presents no general view of the trend of wages in manufactures. It supplies, however, for the first time, trustworthy material that may be used for such an investigation.

In the second of the four chapters of the report an "Analysis of Occupational Comparison" is made by considering the wages of laborers in thirty-two industries. Copies of actual pay-rolls of establishments representative of the several industries were obtained for 1890 and 1900—due precaution being taken that the figures for the two periods should be comparable—and were then combined into general schedules of wages for the respective industries for the two years. By means of these schedules it is now possible to say what proportion of labor of each of the thirty-two industries covered by the report received wages between any given limits in 1890 and in 1900: for example, what proportion of labor in the manufacture of cotton received wages at the rate of nine to ten dollars a week.

In order to form an idea of the trend of wages in manufactures from 1890 to 1900, I have combined the schedules of the different industries in the same way that the schedules of the individual establishments were combined by the census office to give a general view of the wages of separate industries. The figures taken for these industries are those given in the "Wages" volume, in the case of each industry, under the heading: "Males 16 years and over: Rates per week: All sections: All occupations." It was believed that an investigation confined to this category would be most representative of the general condition of labor.

The thirty industries selected include all schedules fulfilling the above conditions. The two industries omitted from the full number given by the census volume are "collars and cuffs," and "distilleries." The former is not included because no schedule is given for males sixteen years and over, and the latter is omitted because the few figures tabulated relate only to the states of Kentucky and Ohio.

The thirty industries are: (1) carpet mills, (2) cotton mills, (3) dyeing and finishing textiles, (4) knitting mills, (5) woolen mills, (6) agricultural implements, (7) furniture, (8) lumber and planing mills, (9) pianos, (10) wagons and carriages,

(11) car and railroad shops, (12) foundries and metal working, (13) iron and steel, (14) shipyards, (15) bakeries, (16) breweries, (17) candy, (18) chemicals, (19) cigars, (20) clothing, (21) flour mills, (22) glass, (23) paper mills, (24) potteries, (25) printing, (26) rubber, (27) shoes, (28) slaughtering, (29) tanneries, (30) tobacco.[1] These representative industries may be classified in four divisions: textiles, which include the first five industries; wood-working industries, which comprise industries (6) to (10); metal-working industries, (11) to (14); miscellaneous industries, (15) to (30).

The results of the combination of the thirty schedules is recorded in Table I. It will be noted that the inquiry concerns the wages of 160,055 laborers in 1900, and of 104,923 laborers in 1890. The computation of the three fundamental measures of the two groups of wages gives the values here tabulated:

	AVERAGE WEEKLY RATE	RATIO	STANDARD DEVIATION	RATIO	COEFFICIENT OF VARIATION	RATIO
1900	11.52	996	5.017	.945	43.5	.948
1890	11.57		5.309		45.9	

This table justifies the following statements as to the changed condition of rates of money wages in the two groups of laborers selected by the census office to represent manufactures in 1890 and 1900.

(1) The average wage was less in 1900 than in 1890.

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[1] The schedules may be found on the following pages of the Wages volume: (1) carpet mills, p. 5; (2) cotton mills, p. 27; (3) dyeing and finishing textiles, p. 72; (4) knitting mills, p. 81; (5) woolen mills, p. 104; (6) agricultural implements, p. 143; (7) furniture, p. 169; (8) lumber and planing mills, p. 185; (9) pianos, p. 185; (10) wagons and carriages, p. 201; (11) car and railroad shops, p. 225; (12) foundries and metal-working, p. 268; (13) iron and steel mills, p. 325; (14) shipyards, p. 353; (15) bakeries, p. 371; (16) breweries, p. 379; (17) candy, p. 391: (18) chemicals, p. 403; (19) cigars, p. 411; (20) clothing, p. 431; (21) flour mills, p. 461 (includes males under 16); (22) glass, p. 474; (23) paper mills, p. 497; (24) potteries, p. 510; (25) printing, p. 527; (26) rubber, p. 549; (27) shoes, p. 558; (28) slaughtering, p. 580; (29) tanneries, p. 591: (30) tobacco, p. 608.

TABLE I: THE DISTRIBUTION OF WAGES IN MANUFACTURES OF THE UNITED STATES AS REPRESENTED BY THIRTY SELECTED INDUSTRIES

1900			1890		
RATES PER WEEK	NUMBER	PERCENTAGE	RATES PER WEEK	NUMBER	PERCENTAGE
Between $2 & 3	591	.37	Between $2 & 3	444	.42
" 3 " 4	2,646	1.66	" 3 " 4	2,329	2.22
" 4 " 5	4,331	2.71	" 4 " 5	3,723	3.55
" 5 " 6	3,880	2.43	" 5 " 6	2,735	2.61
" 6 " 7	7,926	4.95	" 6 " 7	6,435	6.13
" 7 " 8	15,727	9.83	" 7 " 8	9,529	9.10
" 8 " 9	13,233	8.27	" 8 " 9	8,184	7.80
" 9 " 10	23,686	14.80	" 9 " 10	12,372	11.79
" 10 " 11	18,029	11.26	" 10 " 11	14,545	13.87
" 11 " 12	7,346	4.57	" 11 " 12	4,205	4.00
" 12 " 13	15,412	9.63	" 12 " 13	8,957	8.53
" 13 " 14	9,945	6.22	" 13 " 14	6,117	5.83
" 14 " 15	6,046	3.77	" 14 " 15	3,170	3.02
" 15 " 16	9,223	5.76	" 15 " 16	5,889	5.61
" 16 " 17	5,468	3.42	" 16 " 17	3,431	3.27
" 17 " 18	2,607	1.63	" 17 " 18	1,508	1.44
" 18 " 19	4,466	2.79	" 18 " 19	3,321	3.17
" 19 " 20	1,620	1.01	" 19 " 20	1,273	1.21
" 20 " 21	1,029	.64	" 20 " 21	989	.94
" 21 " 22	1,290	.81	" 21 " 22	1,261	1.21
" 22 " 23	773	.49	" 22 " 23	553	.53
" 23 " 24	571	.36	" 23 " 24	507	.48
" 24 " 25	764	.48	" 24 " 25	603	.57
" 25 " 26	520	.33	" 25 " 26	443	.42
" 26 " 27	224	.14	" 26 " 27	192	.18
" 27 " 28	362	.23	" 27 " 28	353	.34
" 28 " 29	300	.19	" 28 " 29	348	.33
" 29 " 30	175	.10	" 29 " 30	222	.21
" 30 " 31	359	.22	" 30 " 31	307	.30
" 31 " 32	107	.07	" 31 " 32	113	.11
" 32 " 33	131	.08	" 32 " 33	120	.11
" 33 " 34	103	.06	" 33 " 34	110	.11
" 34 " 35	104	.06	" 34 " 35	118	.11
" 35 " 36	73	.05	" 35 " 36	75	.07
" 36 " 37	51	.03	" 36 " 37	53	.05
" 37 " 38	115	.07	" 37 " 38	35	.03
" 38 " 39	195	.12	" 38 " 39	52	.05
" 39 " 40	198	.12	" 39 " 40	35	.03
" 40 " 41	53	.03	" 40 " 41	35	.03
" 41 " 42	41	.03	" 41 " 42	16	.02
" 42 " 43	36	.02	" 42 " 43	13	.01
" 43 " 44	25	.02	" 43 " 44	8	.01
" 44 " 45	23	.01	" 44 " 45	8	.01
" 45 " 46	20	.01	" 45 " 46	12	.01
" 46 " 47	12	.01	" 46 " 47	14	.01
" 47 " 48	16	.01	" 47 " 48	15	.01
" 48 " 49	23	.01	" 48 " 49	22	.02
" 49 " 50	12	.01	" 49 " 50	9	.01
" 50 " over.	168	.11	" 50 " over.	115	.11
Totals	160,055	100	Totals	104,923	100

(2) The standard deviation was less. There was consequently a closer aggregation of labor about the average in 1900, and that average was lower than the average of 1890.

(3) The coefficient of variation was less.

These results are so utterly at variance with what is commonly thought as to the movement of wages that a source of error in the computation was suspected. To shorten the fatiguing arithmetical work which the proposed investigation involved, the wage quotations were, in the first computation, thrown into groups varying by one dollar instead of by fifty cents as given in the census report. In order to eliminate any possible source of error the calculation was made a second time, taking the figures in fifty-cent groups as they appear in the report. The result was an average wage in 1900 of $11.49 and in 1890 of $11.54. Their ratio is .996, the same as the ratio obtained before. This seems to show that no mistake was made in the calculation.

This average is based on all the figures of the thirty industries falling within the limits, two dollars a week to fifty dollars a week. It is impossible to include the quotations below two dollars and above fifty dollars, because no indication is given of their distribution beyond these limits. The omission in both years is less than one-fifth of one per cent of the total number of quotations.

The above results are not put forward as the measures of the wages of the totality of labor in manufactures, but only as measures of the very large groups of wages officially reported as representing the conditions in manufactures. They have the advantage of being independent of any form of weighting and of any theory of index numbers. All three measures are relative to real data.

The question whether the average wage as obtained above is representative of the whole of manufactures could be answered, if the statistical material were available, by computing an average wage in either of two ways: (1) The average wage of the several occupations of the separate industries could be computed from the Wages report, and each occupation accorded an importance proportionate to the number of males, sixteen years and over, in the occupation. The weighted average thus obtained for each of the two years would be entirely satisfactory. (2) The average for each of the separate industries could be computed from the Wages report, and each industry accorded an importance proportionate to the number of males, sixteen years and over, in the industry. This weighted average would be sufficiently representative. But neither of these methods is practicable because of the lack of comparable data for the two periods.[1]

III

It is extremely important to know whether the reduction in variability of wages both absolute and relative which occurred between 1890 and 1900 was due to an increase in the wages of laborers receiving a rate below the average or to a decrease in the relative number receiving wages of skilled labor or to both changes. To settle this question, the absolute distribution of the wages of the two periods, as given in Table I, columns II and V, was reduced to a percentage distribution, which is given in the same Table, columns III and VI. This relative distribution makes possible the comparison of the distribution of the two periods, group for group. The two curves in the chart (p. 71) are drawn to the scale of the percentages, the broken line representing the distribution of 1890, the continuous line the distribution of 1900. The curve for 1900 begins below the curve for 1890, and continues in a lower position until within a short distance of the maximum ordinate; after passing the maximum ordinate at a relatively high point, it descends below the curve for 1890 at a rate of wages not far above the average rate, and thereafter runs almost continuously at a lower level. The obvious interpretation of these facts is that the reduction in variability in 1900 was due to a relative reduction in the number of laborers receiving a wage far below the average, and a similar reduction in the number receiving a wage far above the average.

The curves also show very clearly the aggregation of the wage earners at definite weekly rates, *e.g.*, in 1900 at $7–8,

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[1] Note the warning in volume vii of the Twelfth Census, pp. ciii–cxi.

$9–10, $12–13, $15–16, $18–19, $21–22, $24–25, $27–28, $30–31. These weekly rates are equivalent to daily rates of $1.25, $1.50, $2.00, $2.50, $3.00, $3.50, $4.00, $4.50, $5.00. It is interesting to note that these maximum points are the same for the curve for 1890 except that the *maximum maximorum* of 1900 is a weekly rate of $10–11 or a daily rate of $1.75, while in 1900 it was a weekly rate of $9–10 or a daily rate of $1.50. Assuming that the distribution of efficiency in the two groups of laborers was a continuous distribution, the law of reward according to efficiency would require that the wages curve should approximate a continuous curve. The actual concentration of the laborers in both years, at widely separated peaks, instead of being continuously distributed, suggests either the fallacy of assuming a continuous distribution of efficiency, or a defect in the efficiency theory of wages, or the incompleteness of competition.

IV

Thus far our inquiry has concerned all of the laborers employed in manufactures as represented by the 160,055 laborers in 1900 and the 104,923 in 1890. It is conceivable that the results obtained might be due to the preponderating influence of one or more industries whose wage budgets represented anomalous conditions. Under these circumstances it would be fallacious to say that there is a tendency to a general reduction in the variability of wages in manufactures.

In order to meet this quite natural objection the standard deviations and the coefficients of variation of the thirty industries have been separately computed, and are tabulated in Table II.[1] In the columns headed "Quality of change from 1890 to 1900" the signs of the variations are given respectively for average wages (column VIII), standard deviations (column IX), and coefficients of variation (column X). Out of thirty industries

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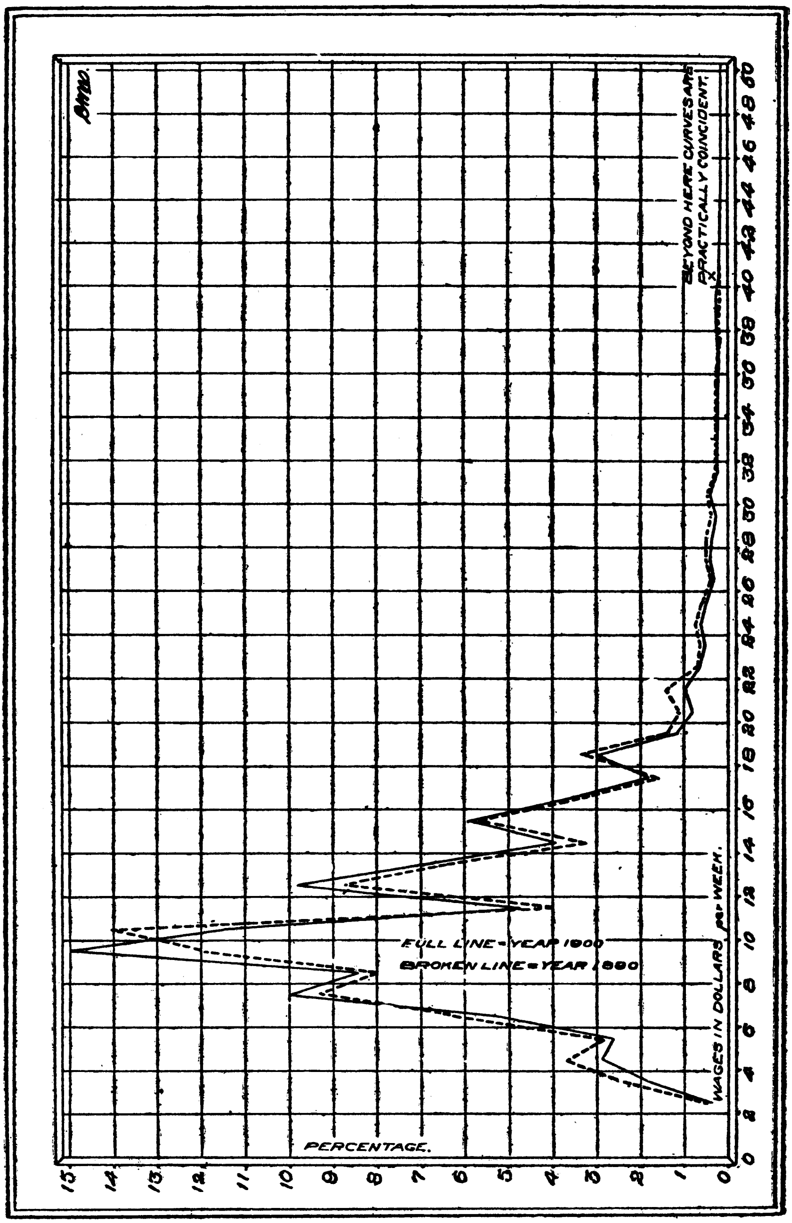
[1] The schedules used are those indicated in a former note, except that in the case of the rubber industry the schedule for the Middle and Central states was taken. All of the figures above two dollars a week were used, except that in case of the iron and steel industry, and in that of the printing industry the unsatisfactory distribution beyond fifty dollars a week made it necessary to confine the computation to rates between two dollars a week and fifty dollars a week.


FULL LINE = YEAR 1900
BROKEN LINE = YEAR 1890
BEYOND HERE CURVES ARE PRACTICALLY COINCIDENT.
WAGES IN DOLLARS per WEEK.
PERCENTAGE.
0
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44
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48
50

TABLE II: CHANGES IN THE VARIABILITY

INDUSTRIES	WEEKLY RATE OF WAGES II		RATIO III	STANDARD DEVIATION IV		RATIO V
	1900	1890		1900	1890	
Agricultural implements	10.96	11.07	.99	3.237	4.259	.760
Candy	8.85	9.16	.966	4.690	4.998	.938
Carpets and rugs	10.17	10.20	.997	4.465	4.523	.987
Car and railroad shops	11.74	12.51	.938	3.939	4.609	.855
Cigars	12.33	12.37	.997	5.481	6.012	.912
Flour mills	12.76	13.32	.958	4.020	5.021	.801
Foundries	11.55	11.57	.998	4.619	4.825	.957
Tanneries	9.67	10.09	.958	3.040	3.187	.954
Slaughtering	11.14	11.15	.999	3.283	3.427	.960
Bakeries	11.80	11.56	1.021	4.416	4.459	.990
Boots and shoes	11.56	11.49	1.001	4.751	5.085	.816
Breweries	14.11	13.80	1.022	4.168	4.553	.915
Chemicals	10.66	10.62	1.004	3.332	3.498	.953
Cotton goods	8.23	8.16	1.008	3.939	4.111	.958
Dyeing and finishing textiles	9.26	9.23	1.003	5.193	5.450	.953
Iron and steel	12.61	12.49	1.010	6.563	6.632	.990
Lumber and planing mills	10.61	10.52	1.008	3.726	3.870	.963
Pianos	11.27	10.75	1.048	5.254	5.842	.899
Potteries	13.82	13.42	1.030	6.525	6.599	.989
Shipyards	12.74	12.63	1.008	4.362	4.833	.902
Wagons and carriages	11.35	10.77	.854	5.539	5.589	.991
Clothing	11.57	13.00	.890	6.856	6.911	.992
Furniture	9.98	10.68	.934	4.367	4.568	.956
Printing	15.97	16.98	.940	7.549	7.761	.953
Woolen goods	9.46	9.05	1.045	4.417	4.326	1.021
Glass	12.57	12.41	1.013	7.879	7.203	1.094
Knitting mills	10.02	9.40	1.066	5.272	4.870	1.082
Rubber	9.06	8.85	1.024	3.077	2.844	1.082
Tobacco	6.37	6.30	1.011	3.493	3.088	1.131
Paper and wood pulp	10.44	10.65	.980	3.477	3.266	1.065

twenty-four have a diminished standard deviation and twenty-two a diminished coefficient of variation. We may observe that this particular case illustrates the truth of the statement made in the earlier part of this paper, that vital changes in the conditions of labor may occur without any indication of the changes appearing in the average wage.

In an article on the "Paradoxes of Competition"[1] I tried to show the great danger to economic theory as well as to practical interests of the common tendency of projecting conclusions that

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[1] *Quarterly Journal of Economics*, February, 1906.

OF WAGES IN THIRTY SELECTED INDUSTRIES

COEFFICIENT OF VARIATION		RATIO	QUALITY OF CHANGE FROM 1890–1900		
VI		VII	VIII	IX	X
1900	1890		*See* III	*See* V	*See* VII
29.5	38.5	.77	—	—	—
53.0	54.6	.97	—	—	—
43.9	44.3	.99	—	—	—
56.6	36.9	.99	—	—	—
44.4	48.6	.91	—	—	—
31.5	37.7	.84	—	—	—
40.0	41.7	.96	—	—	—
31.4	31.6	.99	—	—	—
29.5	30.7	.96	—	—	—
37.4	38.6	.97	+	—	—
41.1	44.2	.93	+	—	—
29.5	32.9	.90	+	—	—
31.3	32.9	.95	+	—	—
47.9	50.4	.95	+	—	—
56.1	59.0	.95	+	—	—
52.1	53.1	.98	+	—	—
35.1	36.8	.95	+	—	—
46.6	54.3	.86	+	—	—
47.2	49.2	.96	+	—	—
34.2	38.3	.89	+	—	—
48.8	51.9	.94	+	—	—
59.3	53.2	1.11	—	—	+
43.8	42.8	1.02	—	—	+
47.3	45.7	1.03	—	—	+
46.6	47.8	.98	+	+	—
62.6	58.0	1.08	+	+	+
52.6	51.8	1.02	+	+	+
34.0	32.1	1.06	+	+	+
54.8	49.0	1.12	+	+	+
33.3	30.7	1.08	—	+	+

are relative to a hypothetical state into the complex and theoretically unexplored territory of actual industry. It was there stated that the danger is especially great in the treatment of the theory of wages. The above investigation suggests a warning to be equally on guard against the common fallacy of inferring from an average or an index number of wages conclusions as to the general condition of labor.

HENRY L. MOORE.